

# The Invasive Species Forecasting System: Space-Based Decision Support for Invasive Species Management



J.W. Closs<sup>1,2</sup>, N.F. Most<sup>1,4</sup>, D.J. Kendig<sup>1,2</sup>, M.A. Kalkhan<sup>3</sup>, J.T. Morissette<sup>1</sup>, J.A. Pedelty<sup>1</sup>, T.J. Stohlgren<sup>3</sup> and J.L. Schnase<sup>1</sup>.

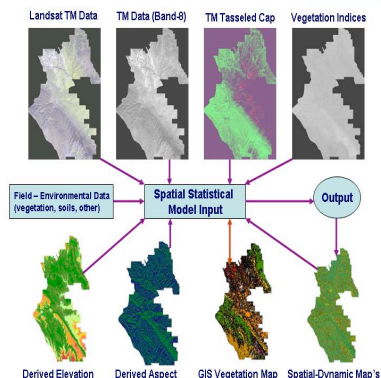
<sup>1</sup>NASA Goddard Space Flight Center, Earth and Space Data Computing Division, Greenbelt, MD

<sup>2</sup>Science Systems and Applications, Inc., Lanham, MD

<sup>3</sup>Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO

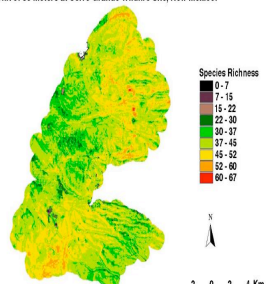
<sup>4</sup>Intelview, Greenbelt, MD

The NASA Office of Earth Science and the US Geological Survey are working together to develop a National Invasive Species Forecasting System for the detection, remediation, management, and control of invasive species on Department of Interior and adjacent lands. The project is a broadly interdisciplinary effort that brings together ecologists, scientists, statisticians, natural resource managers, policy makers and others who share an interest in the invasive species challenge.



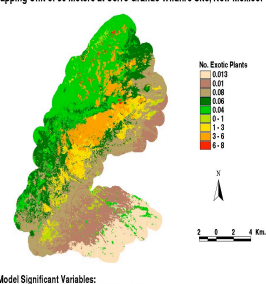
High resolution mapping of biological resources is central to confronting the invasive species threat and forms the basis of the Invasive Species Forecasting System. The ability to model small scale variability in landscape characteristics requires the generation of full coverage maps depicting characteristics measured in the field. While many spatial datasets describing land characteristics have proven reliable for macro scale ecological monitoring, these relatively coarse scale data fall short in providing the precision required by more refined ecosystem resource models. Spatial statistics and geostatistics provide a means of developing spatial models that can be used to correlate coarse scale geographical data with micro scale field measurements of biotic variables.

Predicted Spatial Map for Total Plant Species Richness with Mapping Unit of 30 Meters at Cerro Grande Wildlife Site, New Mexico.



Model Significant Variables:  
Elevation, Slope, Vegetation Index (TMNDVI), and  
TM-Tasseled Cap (Band1); with R<sup>2</sup> = 63.9 %.

Predicted Spatial Map for Number of Exotic Species Richness with Mapping Unit of 30 Meters at Cerro Grande Wildlife Site, New Mexico.



Model Significant Variables:  
UTM-X, UTM-Y, Native Plants, TM-Band (4),  
Vegetation Index (Bands 54, 48, NDVI), and  
TM-Tasseled Cap (Band 5); with R<sup>2</sup> = 88.2 %

<http://InvasiveSpecies.gsfc.nasa.gov>

The ISFS is a Web-based information management and modeling environment tailored to the needs of the invasive species community. The system provides a framework for using USGS's early detection and monitoring protocols and predictive models to process MODIS, ETM+, ASTER and commercial remote sensing data, and create on-demand, regional-scale assessments of invasive species patterns and vulnerable habitats.

## ISFS Ingest

Input Variables (150+)  
Remotely Sensed data:  
(ETM, SPOT, MTI, EO1)  
Derived Remote Sensing  
(Vegetation, Indices, PCA  
Tasseled Cap, others)  
Biotic/Abiotic Data:  
Topographic Data  
Species Data  
Vegetation-Forest Data  
Soils Characteristics  
Crypobiotic Crusts  
Wildfire Severity  
Biodiversity  
Air Pollution  
Geology, Other  
Environmental Data

## ISFS Modeling

Trend Surface Analysis  
With Stepwise Multiple  
Regression Using  
OLS, GLS, SAR, or  
\* Exhaustive Regression

Testing for spatial auto-  
correlation  
in the residuals

Testing if Residuals  
Cross-Correlated with  
Other Variables

Regression  
Trees  
Classifications

Model Residuals  
Using \* Kriging \*  
(Universal,  
Ordinary, other)

Model Residuals  
Using Co-Kriging

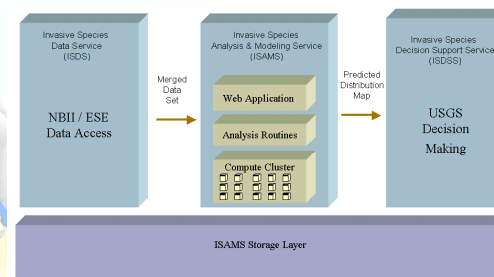
## DSS Products

Output  
GIS - Spatial  
Statistical Dynamic  
Models and Maps  
Hot spots of native  
biodiversity  
Distribution of non-native  
species  
Barriers to rapid invasions  
Corridors that may  
Accelerate invasions  
Economic and environmental  
Risk assessments,  
Vulnerability of habitats to  
invasion  
Priorities for control and  
containment

The USGS geostatistical process for creating predictive spatial models accepts as input a collection of ecological attributes, such as topographic data, species data, soil characteristics, ETM+ - derived vegetation indices, etc. These attributes are examined for statistically viable relationships between predictor variables and response variables. Trend surface analyses are performed, and residuals from the analyses are further analyzed for spatial structure using kriging and co-kriging (a spatial interpolator that determines the best linear unbiased estimate of the value at any given pixel in an output surface or image using a weighted sum of the values measured at arbitrary sample locations).

The results are brought together to produce a refined spatial prediction that is accompanied by an estimate of uncertainty. It is important to emphasize that the process's ability to produce both predictive maps and a maps of uncertainty significantly increases its value for decision support, since useful predictions are ultimately dependent upon a quantifiable understanding of error.

## ISFS Services



## ISFS Front End Layer:

Graphical User Interface offering users universal access to the system.

## ISFS Application Layer:

**Ingest** — The ingest subsystem will serve as the initial "entry point" for all data used in the system, offering users the capability of uploading data to be used by the system and merging ingested datasets to create a data product that can be analyzed in the modeling step. The ingest subsystem is being designed as an independent service called the Invasive Species Data Service.

**Modeling** — The modeling subsystem allows users to apply high-performance statistical algorithms to predict the large-scale distribution of invasive species throughout a habitat of interest.

**Decision Support System** — Results from the modeling activities provide products in the form of images and corresponding data for user analysis in formal and informal decision support systems.

## ISFS Back End/Storage Layer:

An archive subsystem coordinates interactions with databases to allow personal and public storage of data and modeling results.

